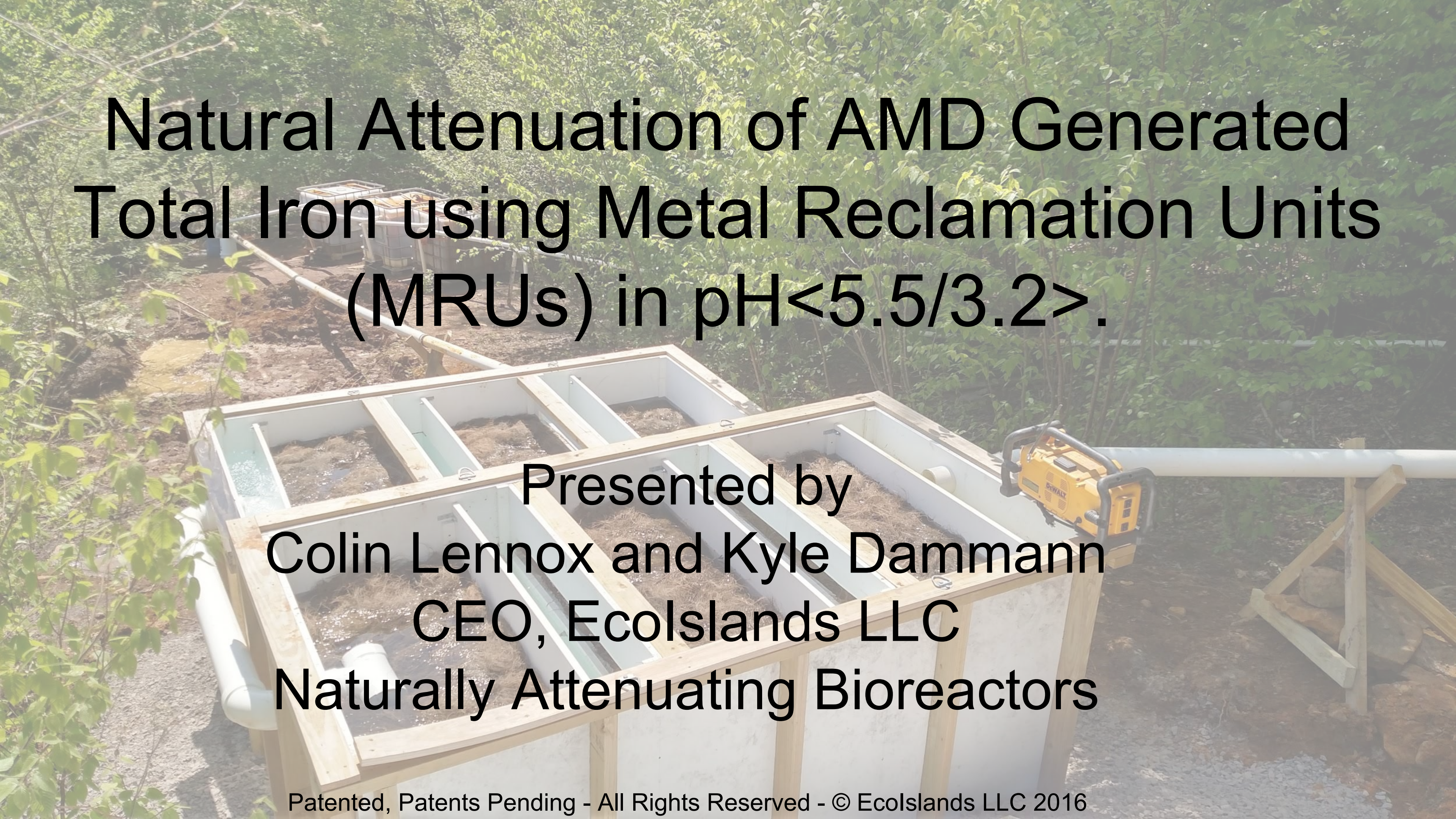

# Metal Removal Units (MRUs, Wetlands in a Box) for AMD and Nutrient Cycling, C. Lennox


BIOMINING



# Natural Attenuation of AMD Generated Total Iron using Metal Reclamation Units (MRUs) in pH<5.5/3.2>.


Presented by
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CEO, EcoIslands LLC
Naturally Attenuating Bioreactors

# Squatter Falls, In Association with the Altoona Water Authority Pilot Study, November 2015 - 16

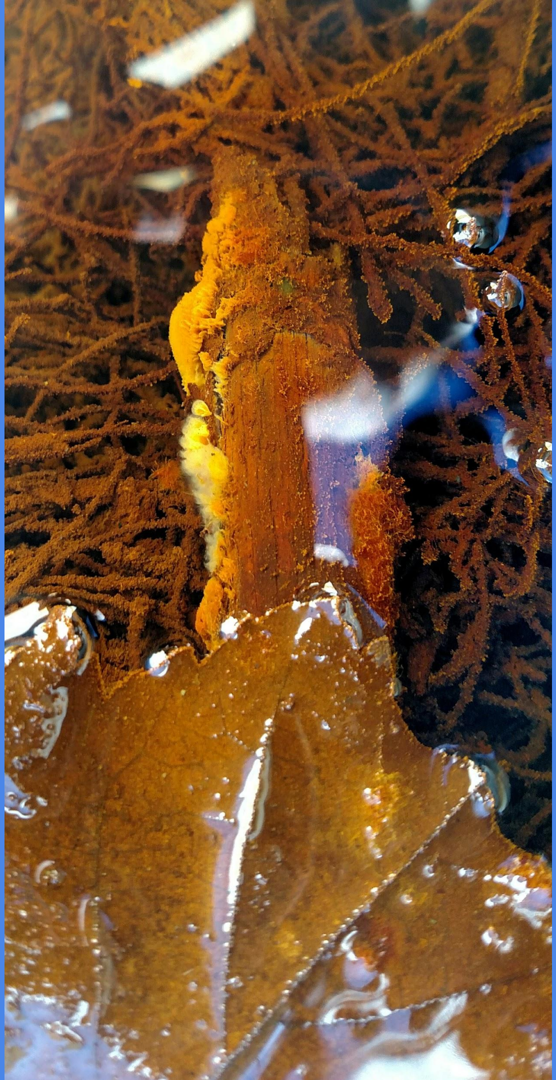
Squatter Falls 2
Squatter Falls Pilot
© 2016 Google
60 ft
1993
Imagery Date: 10/11/2015 40°30'16.37" N 78°30'55.17" W elev 1913 ft eye alt 2131 ft
Google earth

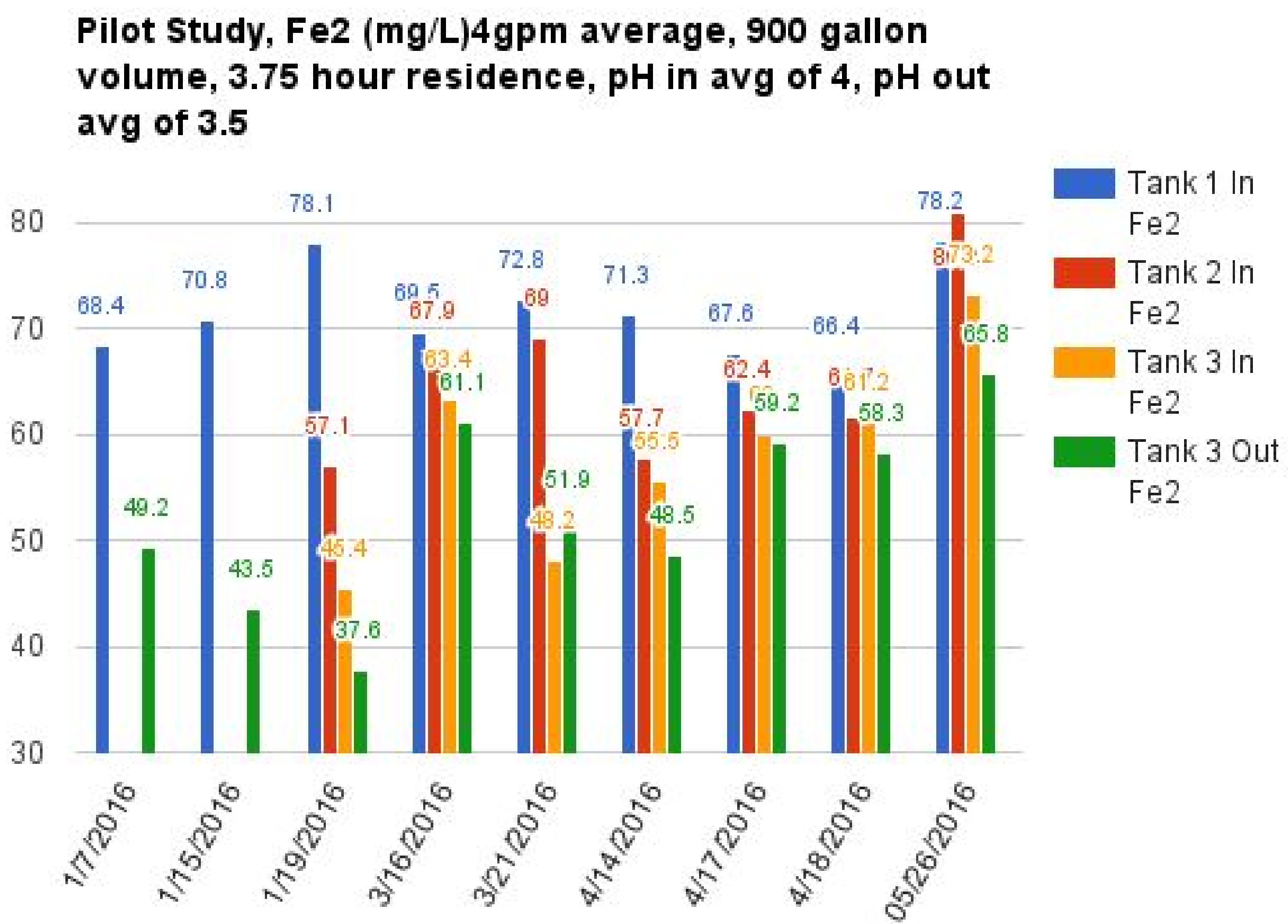
# Chemo-autotroph (ex. A. ferrooxidans, archaea, bacteria, and a few fungi)  Dissolved/Reduced Fe2 as electron donor/energy source), carbon dioxide as C source

Additional Iron depositional growth occurred in the corners of the prototypes, limiting short circuiting, but only after the center of the treatment mass has filled in and sent flow to the corners.

- Fe2 removal, Influent late fall/winter 5.3/3.8 pH at MRU influent in the near absence of Alkalinity (lab <20 mg/l). MRU Out fall/winter 3.8/3.5pH
- Total Fe removal average = 2.5kg/day/(2) MRu Mk2's (summer data)

Chemo Heterotrophic, requiring an organic form of Carbon

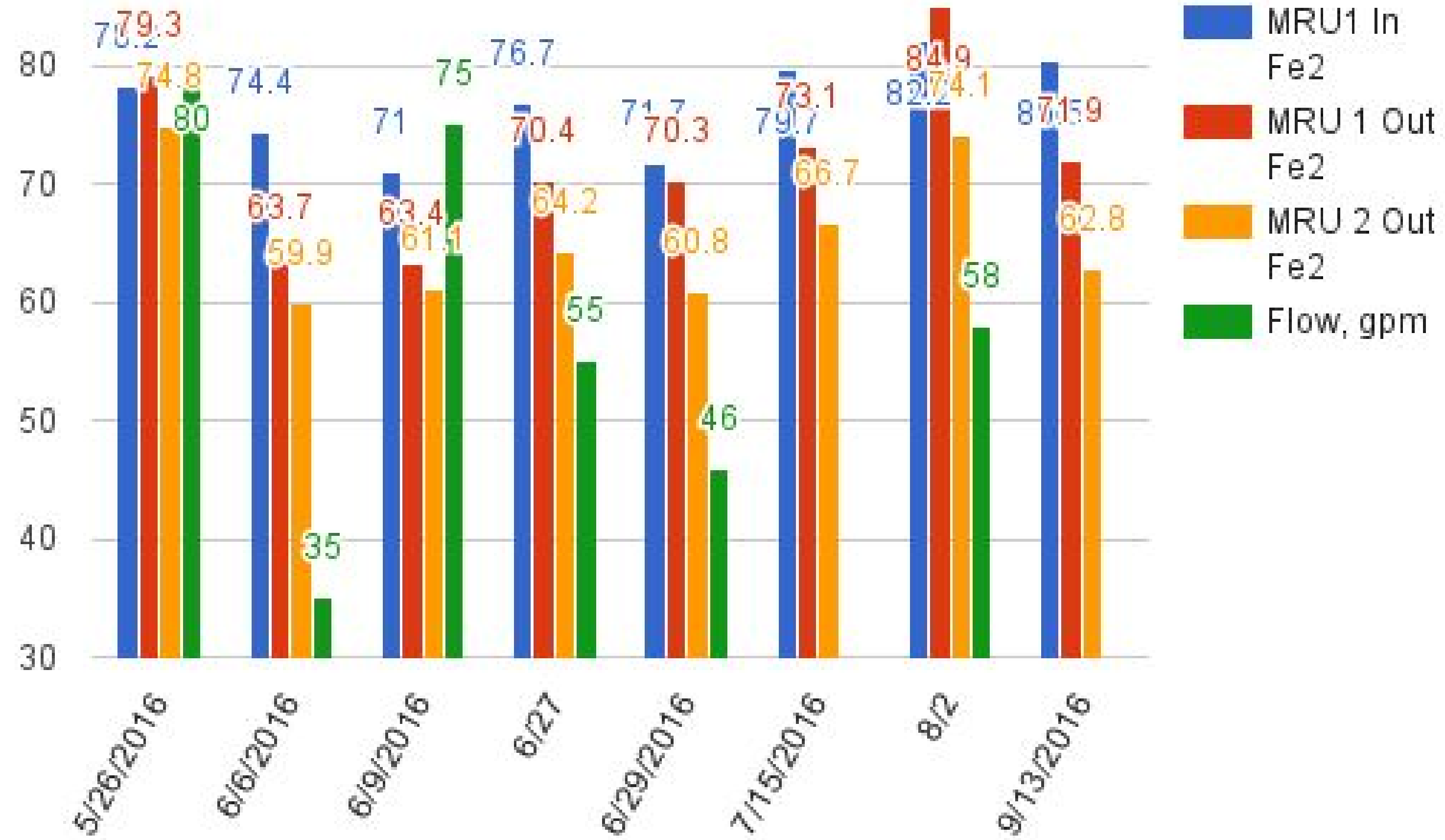


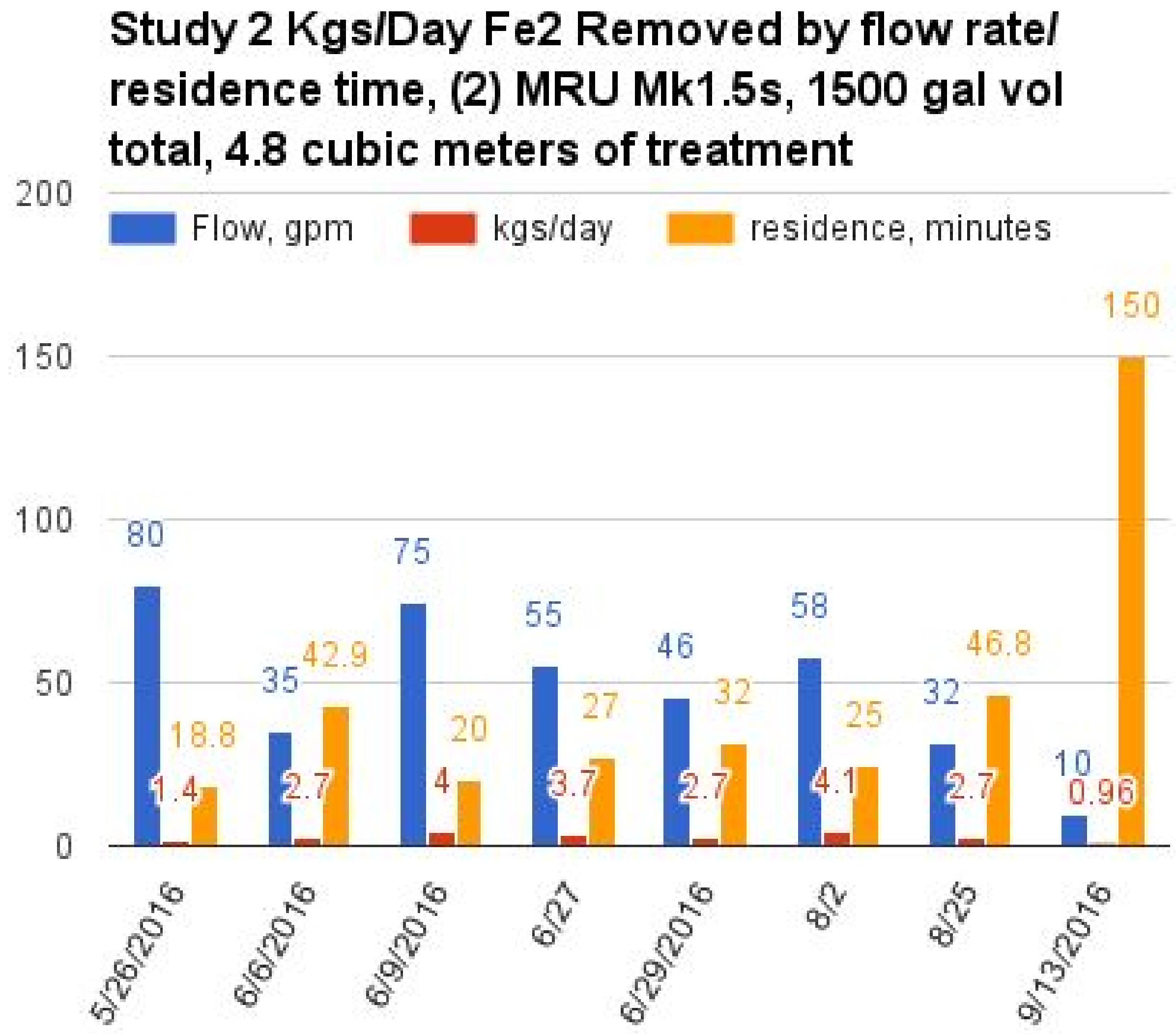

Pilot Study, Fe2 (mg/L)4gpm average, 900 gallon volume, 3.75 hour residence, pH in avg of 4, pH out avg of 3.5
Tank 1 In Fe2
Tank 2 In Fe2
Tank 3 In Fe2
Tank 3 Out Fe2
80
70
60
50
40
30
1/7/2016
1/15/2016
1/19/2016
3/16/2016
3/21/2016
4/14/2016
4/17/2016
4/18/2016
05/26/2016
68.4
49.2
70.8
43.5
78.1
57.1
45.4
37.6
69.5
67.9
63.4
61.1
72.8
69
48.2
51.9
71.3
57.7
55.5
48.5
67.6
62.4
59.2
66.4
61.2
58.3
78.2
73.2
65.8

- (2) Mk1.5 MRUs
- Pilot study, disassembled in background
- Overflows shown to demonstrate internal overflow controls when a treatment chamber reaches saturation.

# Study 2
# 5/26/16-9/13/16

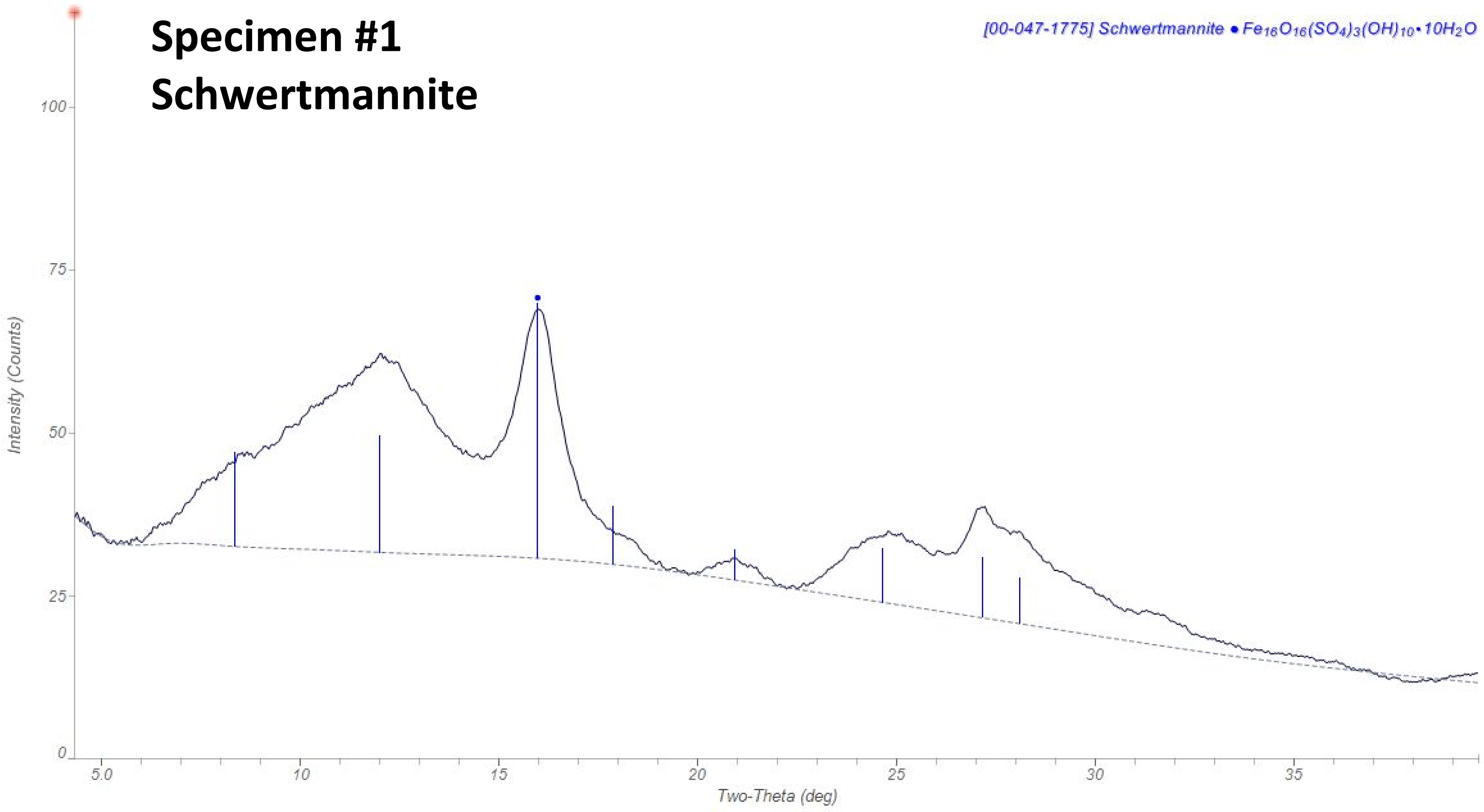
## Study 2, Fe2( mg/L) removal through biotic and abiotic means. (2) Metal Reclamation Units Mk1.5 in series.



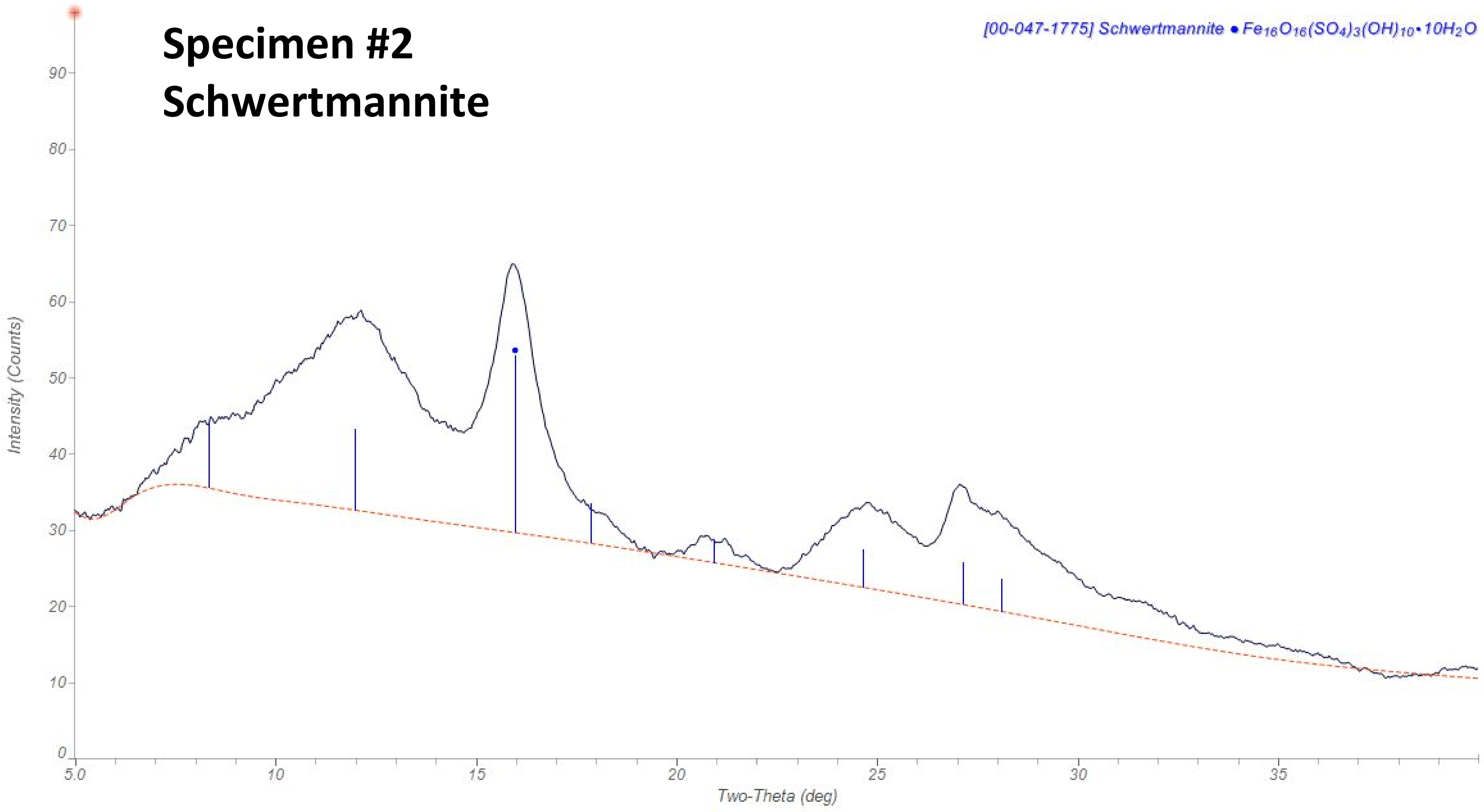


Study 2 Kgs/Day Fe2 Removed by flow rate/ residence time, (2) MRU Mk1.5s, 1500 gal vol total, 4.8 cubic meters of treatment
200
150
100
50
0
Flow, gpm
kgs/day
residence, minutes
80
1.4
18.8
35
2.7
42.9
75
4
20
55
3.7
27
46
2.7
32
58
4.1
25
32
2.7
46.8
10
0.96
150
5/26/2016
6/6/2016
6/9/2016
6/27
6/29/2016
8/2
8/25
9/13/2016

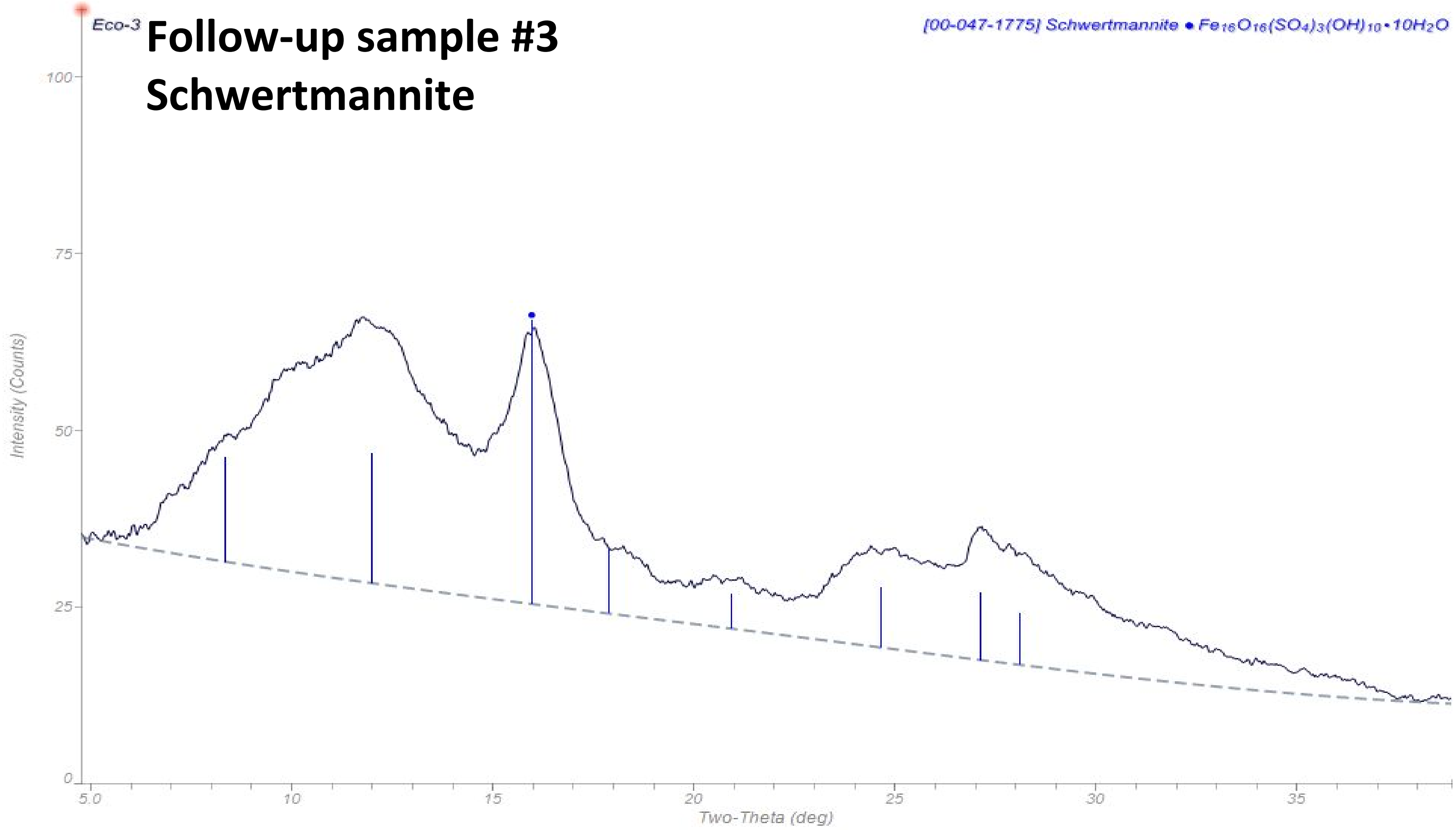
# Specimen #1
# Schwertmannite



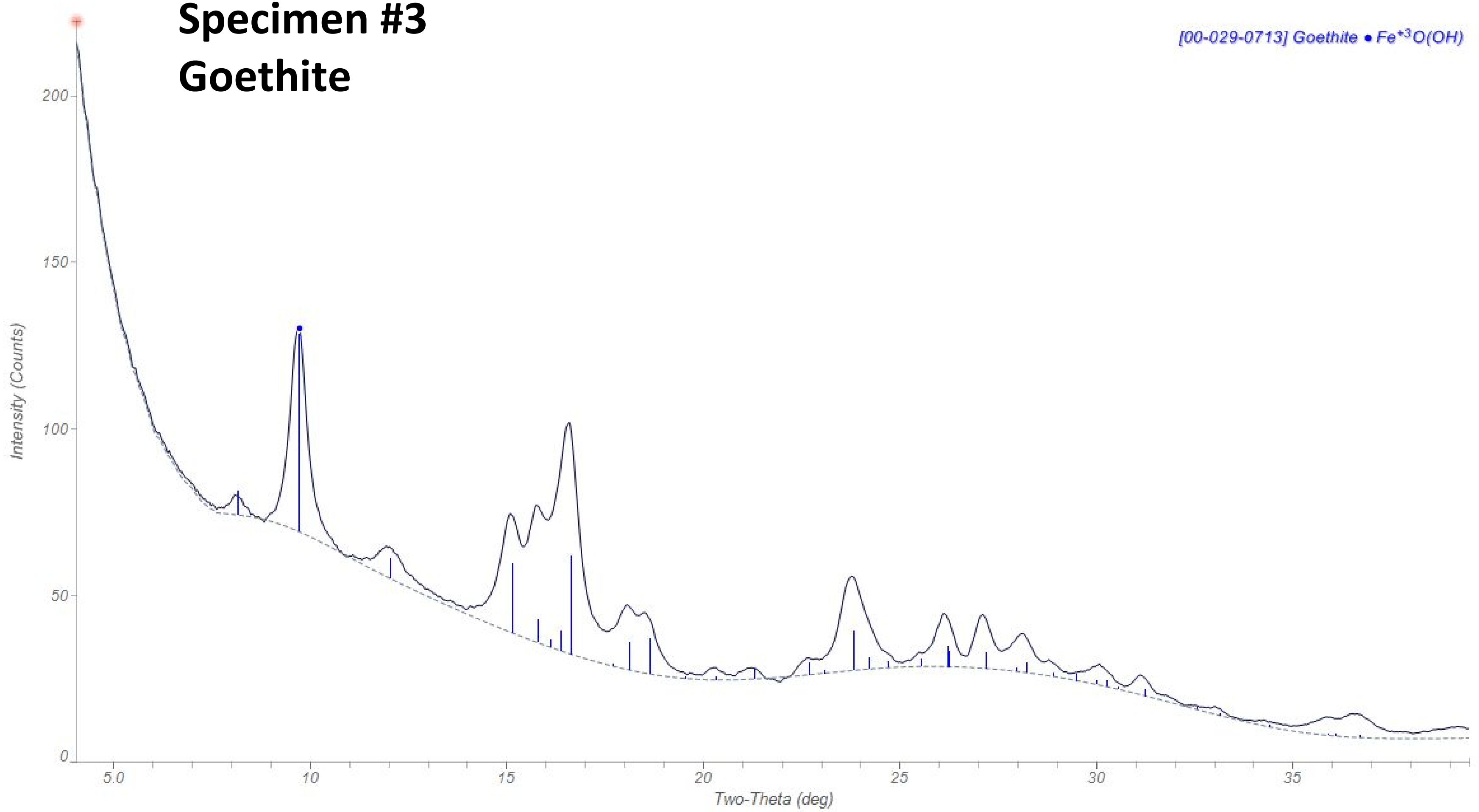
**Specimen #2**
**Schwertmannite**



# Follow-up sample #3
# Schwertmannite



# Specimen #3
# Goethite

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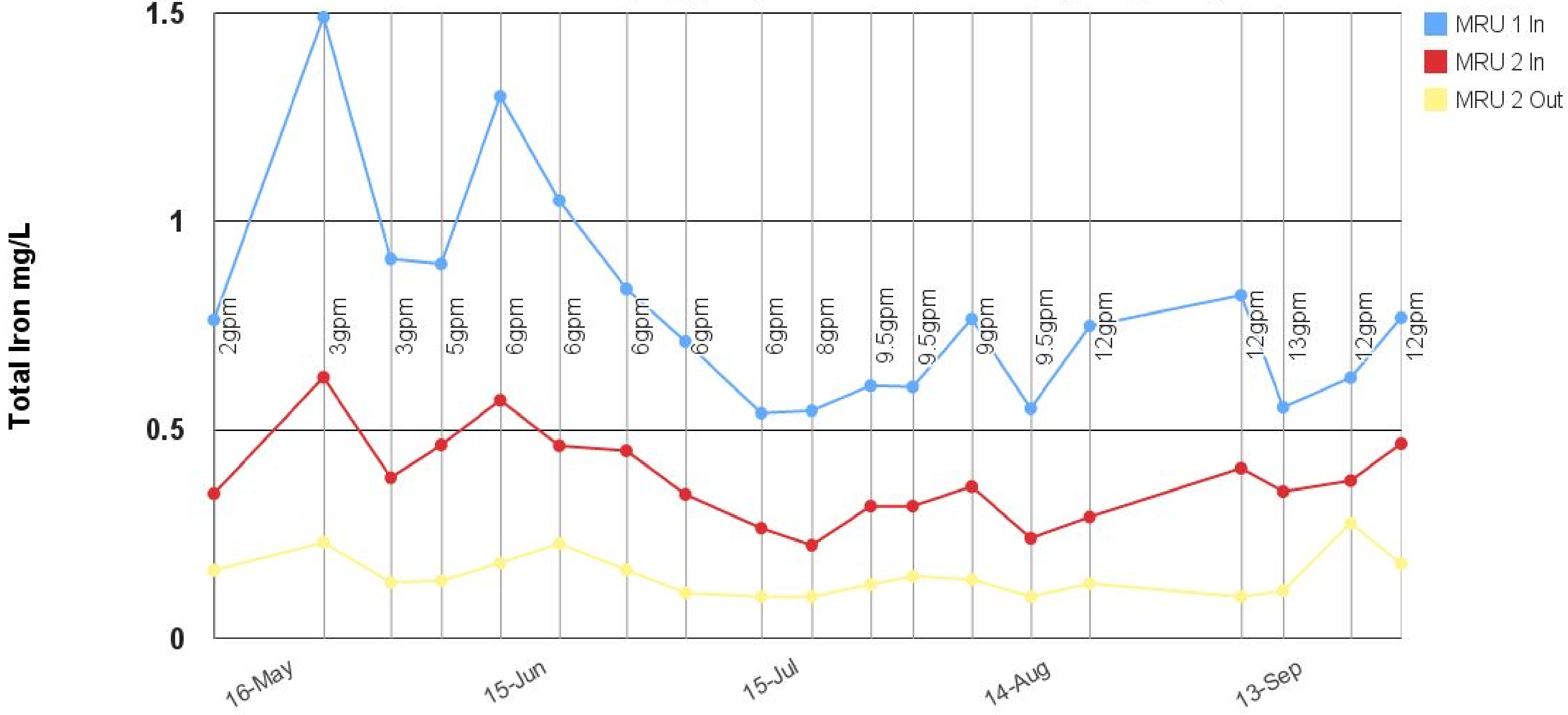
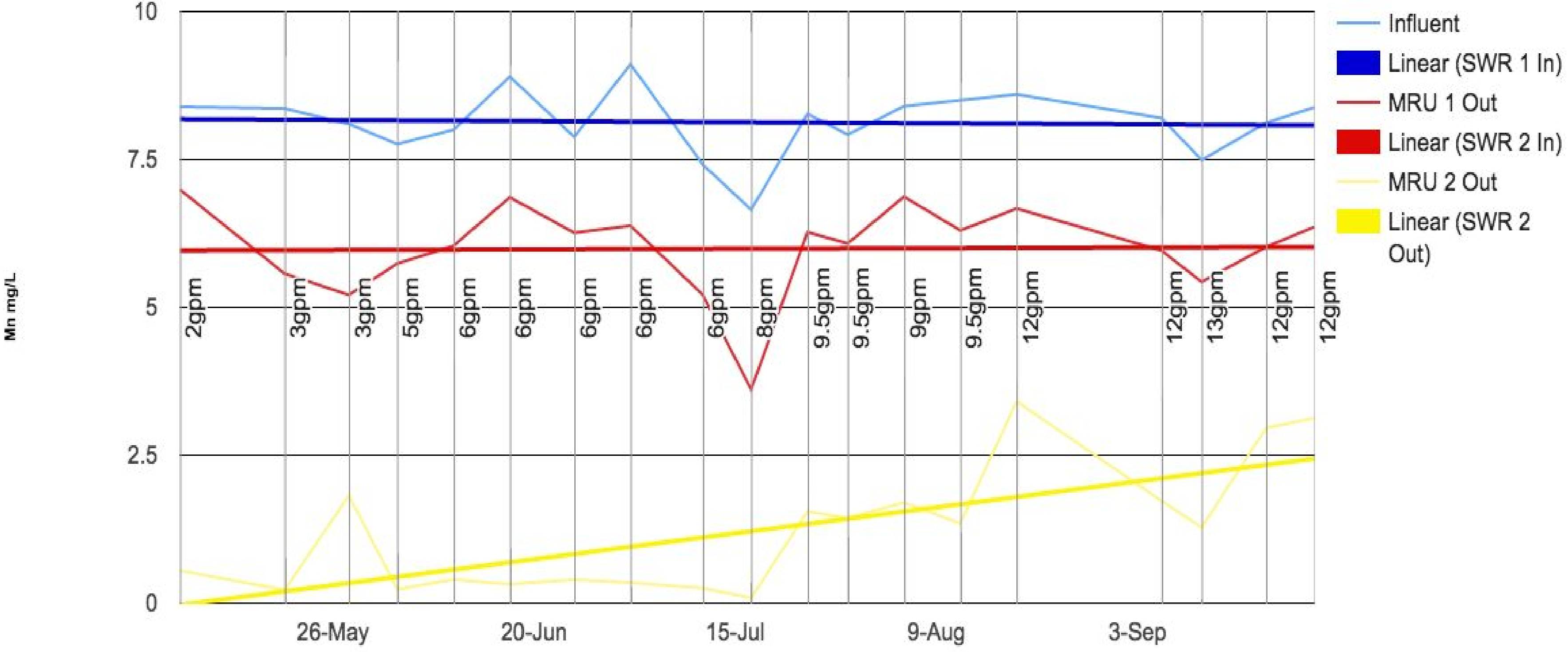
Early Prototype MRUS at Flight 93 Nat. Memorial and Glasgow 2013

## Figure E, Flight 93 Memorial, 2013 Total Iron Removal Comparisons, app 530 Gallon Total Volume, Residence Time of 176 minutes (3gpm) to 44 Minutes (12gpm).

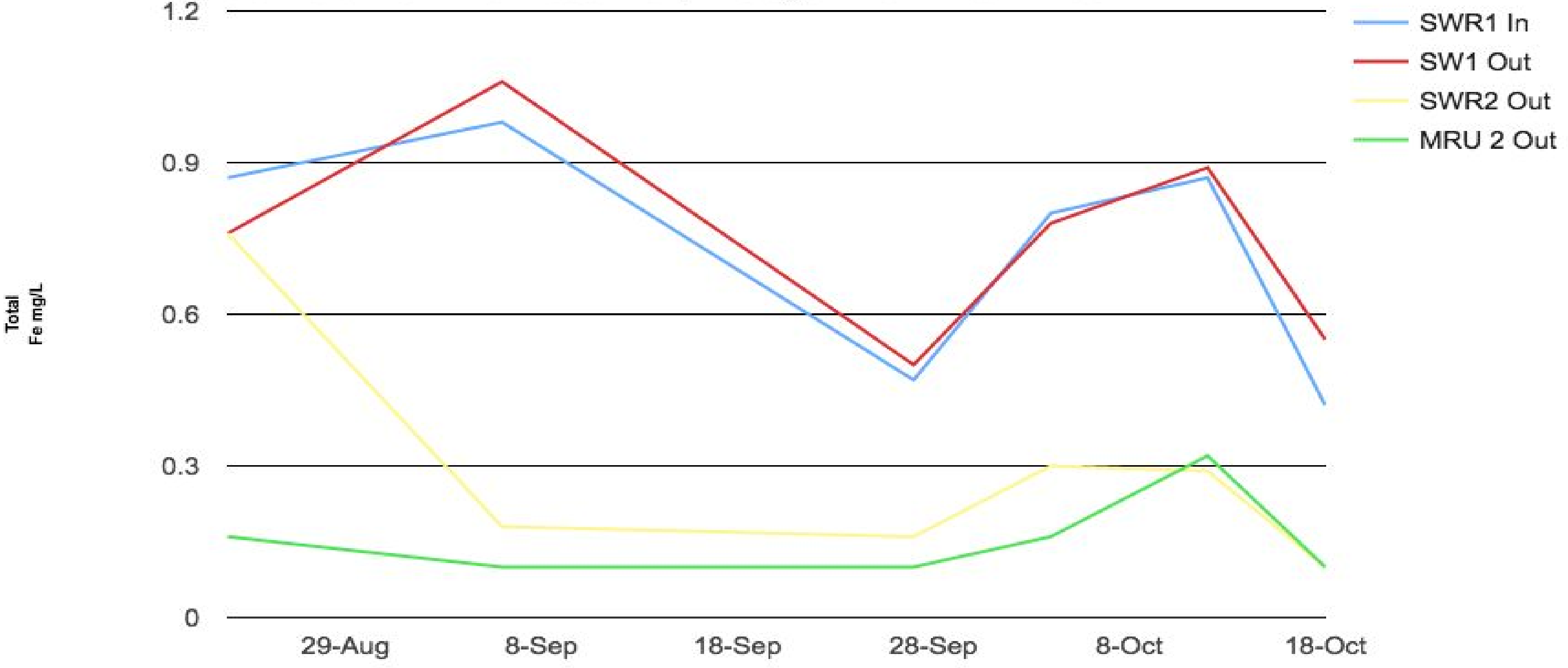


## Figure F, Flight 93 Memorial, Manganese Removal, 530 Gallon app Total Volume, Residence Time of 176 Minutes (3gpm) down to 44 Minutes (12gpm).



# Glasgow Early Prototype MRUs 2012-13

**Figure I, Glasgow, 2013, Total Iron Comps, 5.8 gpm app, 1365 gal volume, 235 Minutes ResidenceNote: SWR 1 is saturated with material, removing it from treatment. Rates of removal derived from new total vol, 1190gal. New Res = 205 Min.**



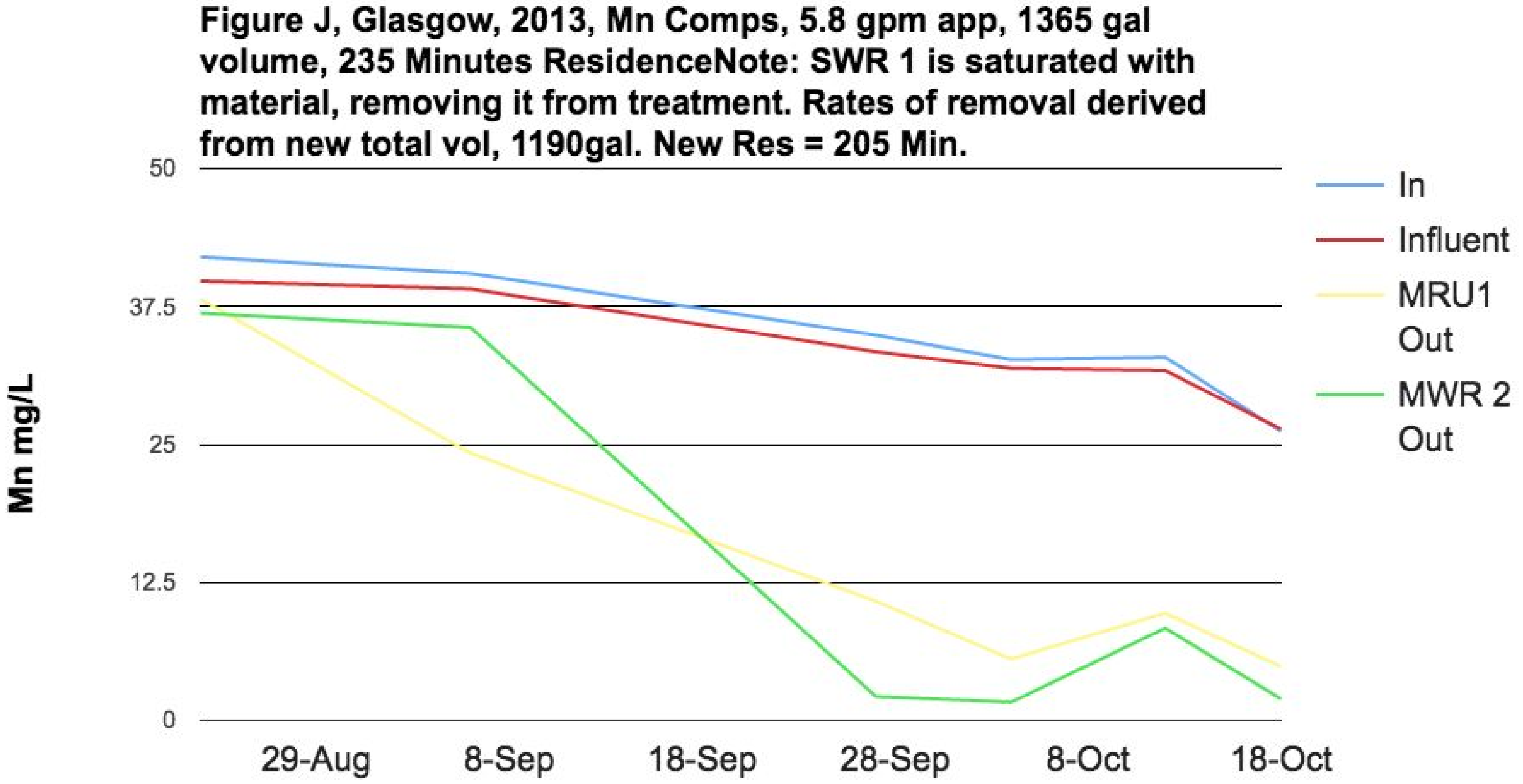
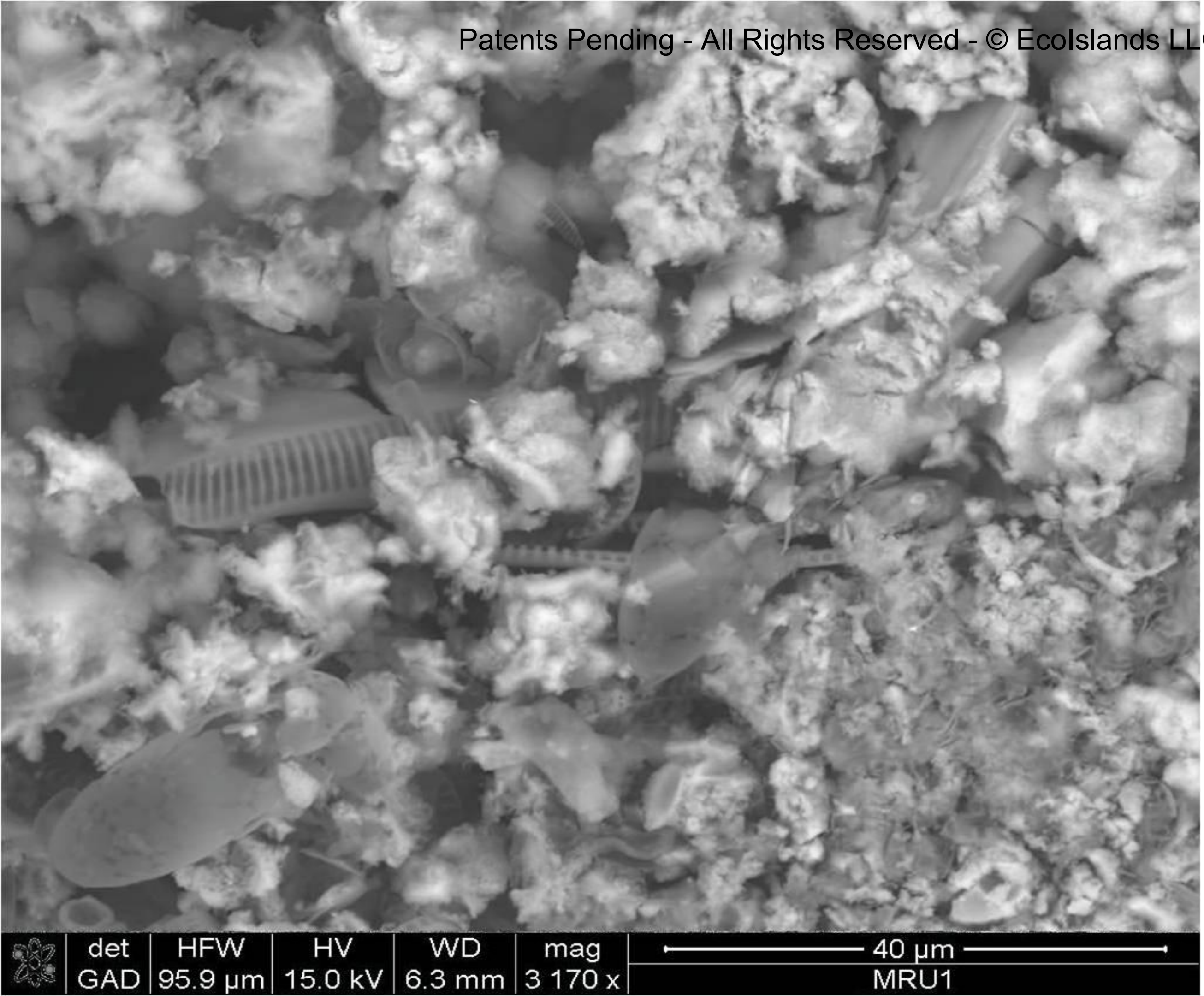


Figure J, Glasgow, 2013, Mn Comps, 5.8 gpm app, 1365 gal volume, 235 Minutes ResidenceNote: SWR 1 is saturated with material, removing it from treatment. Rates of removal derived from new total vol, 1190gal. New Res = 205 Min.
Mn mg/L
50
37.5
25
12.5
0
29-Aug
8-Sep
18-Sep
28-Sep
8-Oct
18-Oct
In
Influent
MRU1 Out
MWR 2 Out

“{(5 gal/min) * (23 mg Mn/L)]/24 ft^2) * (1/1000) (g/mg) * 3.78 (L/gal) * 1440 (min/day) * 10.76 (ft^2/m^2) = **281 (g Mn/d*m^2).**

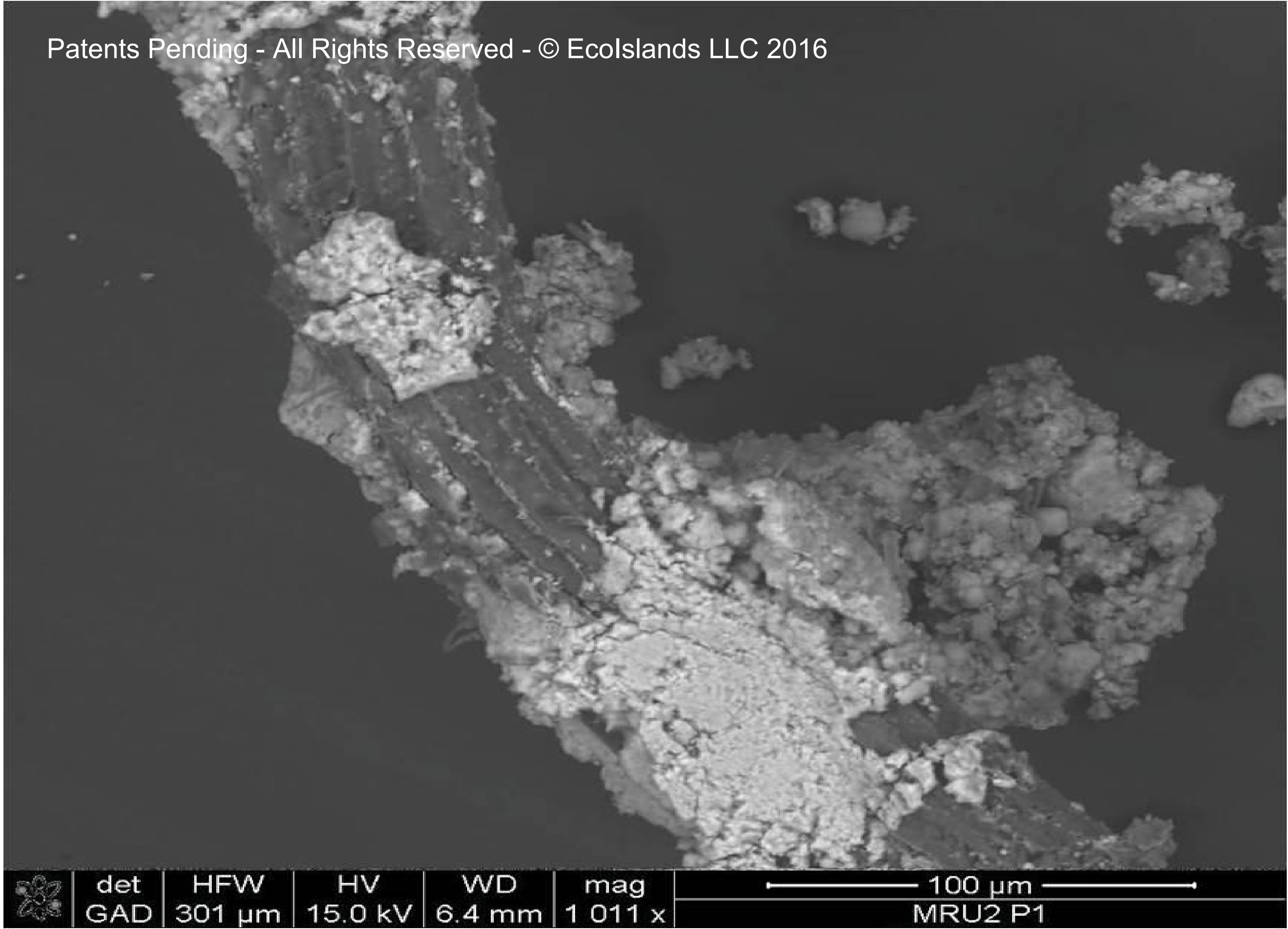
We examined 8 conventional limestone-based Mn removal beds and calculated GDM values of ~2 – 10 (g Mn/d*m^2) (see Santelli et al. 2010). Your unit is 28 – 140 times better than any of those!” (W. Burgos, 2014, personal correspondence concerning Glasgow calculations.)




Manganese Dioxide, identified as rancieite mixed with diatoms, SEM. (Ling. F. 2014. Glasgow Site.)

# Coir and Mn Oxide particles

(Ling, F. 2014.Glasgow Site.)



Burgess, Sherpa Mining, Mk3.18 and (2) Mk3.075’s in series, Nov 2016

# Mini MRU, ¼ Scale, as aquaponics mesocosm







# DARPA Grant, SB 163-02

- Genetic or Genomic Solutions to Insect Production for primary or secondary human consumption.

- Ecological solutions, not genetic
- MRUs are excellent aquaculture tanks.  Surface Area, Gas Exchange, Selectable Reduction or Oxidation
- Self select for nitrifiers to fix NH4 to NO3.
- Additional diverse primary producers for trophic fixation.

# Bibliography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